CHAPTER 3

Factors Affecting Puget Sound Salmon and Bull Trout

Habitat Factors Affecting Puget Sound Chinook Salmon and Bull Trout

"Puget Sound is like a large water bucket, full of habitat and life. Habitat losses are the holes in the bucket, and many small holes can eventually drain it. Restoration is the process of plugging the holes while protection is to prevent new holes from being formed, allowing the bucket to fill once again through natural processes."

Jacques White, The Nature Conservancy

Puget Sound settlers and tribes in the 19th Century were so accustomed to the abundance of salmon that shortages were unthinkable. Salmon had been a constant and reliable part of the tribal diet for millennia, and were an important source of sustenance for pioneer families. In 1870, the human population of the entire state numbered less than 24,000, and hundreds of thousands of Chinook salmon returned to Puget Sound rivers. Today these numbers have dramatically reversed. In addition to salmon and other marine resources, early settlers found vast stands of virgin timber, fertile river deltas suitable for agriculture, and numerous bays ideally situated for shipping and commerce. As the face of the Puget Sound landscape changed, so too did the processes that formed and sustained the habitat for salmon.

Numerous reports document the decline of salmon abundance on the west coast of the United States as a result of loss, damage or change in their natural environment. Early logging practices removed the backbone of the watersheds that had been formed by old-growth riparian forests, stripping off shade, protective cover and food supplies for the salmon. Access to important spawning and rearing areas was eliminated as a result of dams, culverts and other barriers. Other important areas for incubation and forage have vanished due to the placement of dikes, fill or structures in riparian zones and estuaries. Patches of habitat have become so fragmented that they are no longer usable by salmon as they move through their life cycle in time and space.

Scientists distinguish between the outright loss of habitat quantity and the loss of ecosystem processes that once served to form and rebuild the variety of habitat structures salmon depend on. The amount of habitat that is usable by salmon is a fraction of what was once present in Puget Sound, and the ability of salmon to recover to sustainable and harvestable levels depends directly on an increase in the quantity of available habitat of sufficient quality. Additionally, effective recovery strategies must focus on restoring the ecosystem processes that build salmon-friendly rivers and estuaries so they will sustain salmon and other ecosystem functions in the long term. Although every restoration project helps, piecemeal actions that are largely "random acts of kindness" for salmon will not achieve long term recovery in the same way as the restoration of fundamental ecosystem functions in the watersheds and estuaries.

Habitat impairments affecting Chinook salmon and bull trout in Puget Sound have been described generically and locally in numerous scientific publications as well as the watershed chapters (see box on next page), thus an exhaustive list and description is not provided in this chapter. The first section provides an overview of the changes in the Puget Sound landscape over the last 100 years and a sample of the changes and impacts in specific watersheds around the region. The following section briefly discusses the relationship of land use

activities to the habitat forming processes upon which salmon depend and describes the technical studies of habitat available for Puget Sound watersheds. The statutory framework and other conservation activities in Washington are discussed later.

Puget Sound Land Use History and Habitat Change

When Captain George Vancouver sailed into the soft grey fog of Puget Sound waters in 1792, an estimated 50,000 Indians lived in scattered villages near most of the river mouths. The Puget Sound tribes were experts at gathering food from the teeming waters of area rivers and bays, and traveled seasonally through well-defined local territories for fishing, hunting and gathering. Fur traders and missionaries soon followed Vancouver and other explorers, putting the region on a trajectory of increasing population growth and accelerated landscape change.

Timber Harvest

Coastal Indians utilized the forest to construct cedar plank longhouses, canoes, weapons, utensils, ceremonial objects and cedar bark clothing. The huge trees formed the structure for salmon and bull trout habitat in Puget Sound watersheds. Interlocking root systems stabilized streambanks and retained soil. As trees fell into the rivers, pools and logjams formed, creating cover and low velocity areas where salmon could rest. Massive logjams moderated water velocity and interrupted the transport of sediment, providing ample areas suitable for spawning. Temperatures were kept cool by the dense shade, and insect production was high, thus salmon emerging from their redds (nests) found plenty to eat. Salmon thrived on the slowly but constantly changing environment, where pools and spawning areas could shift and re-form as wood, water and soil moved downstream. The large trees and rootwads washing down from the upper watersheds continued to provide structure and cover along the saltwater shore zones of Puget

Key documents which describe the factors that have led to the decline of Chinook, bull trout and other species of salmon include:

General information on habitat impacts to salmon:

- "Upstream: Salmon and Society in the Pacific Northwest" (National Research Council, 1996)
- "An Ecosystem Approach to Salmon Conservation" by Management Technology. (Spence, et al., 1996)
- "Factors for Decline: A Supplement to the Notice of Determination for West Coast Steelhead" (NMFS, 1996)
- "Factors Contributing to the Decline of West Coast Chinook Salmon: An Addendum to the 1996 West Coast Steelhead Factors for Decline Report" (NMFS, 1998)

Information on habitat conditions specific to Puget Sound and local watershed areas:

- "Salmon and Steelhead Habitat Limiting Factors" reports for each Water Resource Inventory Area in Washington State (Washington State Conservation Commission, 1998-2004 depending on WRIA)
- "State of Our Watersheds Report: WRIAs 1-23 (Salmon and Steelhead Habitat Inventory and Assessment Program, Northwest Indian Fisheries Commission, 2004)
- "Draft Recovery Plan for the Coastal-Puget Sound Distinct Population Segment of Bull Trout—Olympic Peninsula and Puget Sound Management Units" (USFWS, 2004)
- "State of the Sound 2004" and previous reports of the Puget Sound Action Team
- See also, watershed chapters.

Photo courtesy the Washington State Salmon Recovery Funding Board.

Sound as well, protecting the migrating salmon as they moved through the saltwater.

"Perhaps no other structural component of the environment is as important to salmon habitat as is large woody debris, particularly in coastal watersheds."

(National Research Council, 1996)

The stands of ancient forest remained largely untouched until the 1840's when small mills were constructed to supply building materials for local settlers. The arrival of the trans-continental railroad in the 1870's also brought tough and energetic lumbermen, who greatly accelerated the harvest of trees, and marketed them to the growing population in the East. Enormous tracts of timberland were purchased from the railroad companies, and large mills were constructed throughout Puget Sound ports and railroad terminuses, dumping unprecedented amounts of concentrated nutrients into Puget Sound waters from the production of lumber, pulp and paper.

The most accessible timber was that located along the Puget Sound river systems, and riparian stands in lowland areas were soon liquidated and floated downstream, removing the shade, cover and food supply for salmon. A common practice was that of "splash-damming." On many rivers and streams, small temporary dams were built. Thousands of logs were stored behind these dams, and when the timing was right, the dam was destroyed with carefully placed dynamite charges, sending a wall of water and wood down the channel towards the waiting mills. Miles of salmon habitat were scoured to bedrock by these manmade floods. As Puget Sound residents started to experience the effects of erosion and flooding from poor early timber practices, the industry began to improve harvest methods and protect environmental functions. Many upland areas remained relatively unharmed or were allowed to re-grow and heal, but the long lasting effects from permanent removal of the forest canopy in some locations, loss of the structure provided by massive old-

Timber harvest impacts are not limited to private timberlands.

• 5,451 miles of road development occurs in the Olympic and Mt. Baker-Snoqualmie National Forest land surrounding Puget Sound

• A majority of stream crossings in the national forest road system in the Pacific Northwest cannot tolerate more than a 25-year flow event without the failure of culverts and other structures associated with the road system.

(Report from the Federal Ecosystem Management and Assessment Team; part of the Northwest Forest Plan.)

growth trees along rivers and shorelines, and the erosion from the construction and failure of logging roads continue to degrade aquatic habitat.

Agriculture

The broad, flat river deltas at the mouths of most large Puget Sound rivers attracted settlers anxious to secure a land base and supply farm products to the growing towns. By 1900 the basic farming patterns in western Washington had been established for the next century. Vegetables, bulbs, hops and berries were largely grown in the fertile river deltas, while dairy farming took hold in the foothills near large cities and towns. The expansion of farmland resulted in the removal of streamside vegetation and elevated water temperatures, which reached lethal levels for salmon in some tributaries. Salmon were further impacted by chemical and nutrient fertilizers and fine sediments from farm runoff.

Lowland deltas underwent further modification by agricultural workers who were able to expand their land base and improve crop growth by diking, draining and filling wetland areas and tidal marshes. The loss of these crucial estuarine sloughs and marsh areas for juvenile salmon, needed for their physiological adjustment to saltwater, had a profound effect on the survival of salmon. Recent studies of the Skagit River delta, for example, have estimated that 72% of intertidal and estuarine marsh habitat has been lost, coinciding with the modification of the basin for agriculture and other land uses. Skagit system studies further indicate that the quantity of certain types of delta habitat may have a major effect on juvenile Chinook productivity (Beamer, et al., 2004).

Low flows related to water withdrawals for agricultural irrigation have further stressed both adult and juvenile salmon. In some rivers, water rights were granted to remove instream flows as early as 1896. In the Dungeness watershed alone, over 100 miles of irrigation canals and ditches legally diverted the bulk of the river's flow in the late summer-the peak spawning season for Chinook salmon. Prior to the 1960's, the irrigation outtakes from the river were largely unscreened, and juvenile salmon were lost in the maze of ditches and laterals that wan-

Photo by Dan Kowalski.

dered through the fields. The irrigation system in the Dungeness is largely unique to western Washington, but water withdrawals from surface and groundwater sources are used to water crops in several major river basins of Puget Sound.

Water quality problems have been experienced in several watersheds with high proportions of agricultural land use. In the Nooksack basin, water temperatures reaching the threshold of mortality to salmon have been documented in several tributaries, along with high levels of nitrogen, phosphorous and fine sediments. Several Nooksack tributary streams are included on the list of impaired water bodies under Section 303(d) of the Clean Water Act for warm water temperatures, fine sediments, fecal coliform levels, chemical contamination and low instream flows (WCC, 2002). These problems are not the sole result of agricultural practices, as urban runoff, wastewater treatment and other inputs add to the mix.

Farming practices in the second half of the 20th century incorporated lessons learned from the Great Depression and dust bowl years. National initiatives were implemented to form soil and water conservation districts, and similar efforts were organized in Puget Sound to help control erosion and chemical contamination from agriculture. "Best management practices" for farming were developed and are continually being refined, but the extent of implementation of these practices still varies widely around Puget Sound. Many individual farmers are avid fishermen themselves, and have worked toward the improvement of water quality and quantity in their farming practices, but the cost of these improvements often limits what they can do. Farmers presently struggle to retain economic viability in the face of competitive markets, escalating land values and urban/suburban development pressures. The greatest restoration potential for salmon habitat today probably occurs on these agricultural parcels of land, which still have no pavement or other extensive infrastructure which would be costly to modify or remove in order to restore habitat features.

"Farmers in Snohomish County look toward seven generations, but it's hard to see what will happen in the next seven years."

Aaron Reardon, Snohomish County Executive

Urbanization

Early explorers to Puget Sound immediately recognized the region's geographic potential for commerce and trade, and the ideal configuration of protected harbors with year-round access. Proximity to timber resources also promoted major shipbuilding centers, which occurred in Port Townsend, Tacoma, Everett, Bellingham, Olympia and Seattle. However it was the Alaska Gold Rush of 1897 to 1903 which made Seattle into the largest city and seaport in the Pacific Northwest. The miners used the port to purchase supplies and ship them north, and shipped the gold back to determine its value. Returning miners spent their millions in the Puget Sound economy and often settled in the Seattle area. Between 1900 and 1910 the population of Seattle grew from 81,000 to 237,000 (Lambert, 2001).

Although the urbanization of Puget Sound slowed somewhat during the Great Depression, the advent of World War II and the growth of the aviation industry once again caused the population to soar.

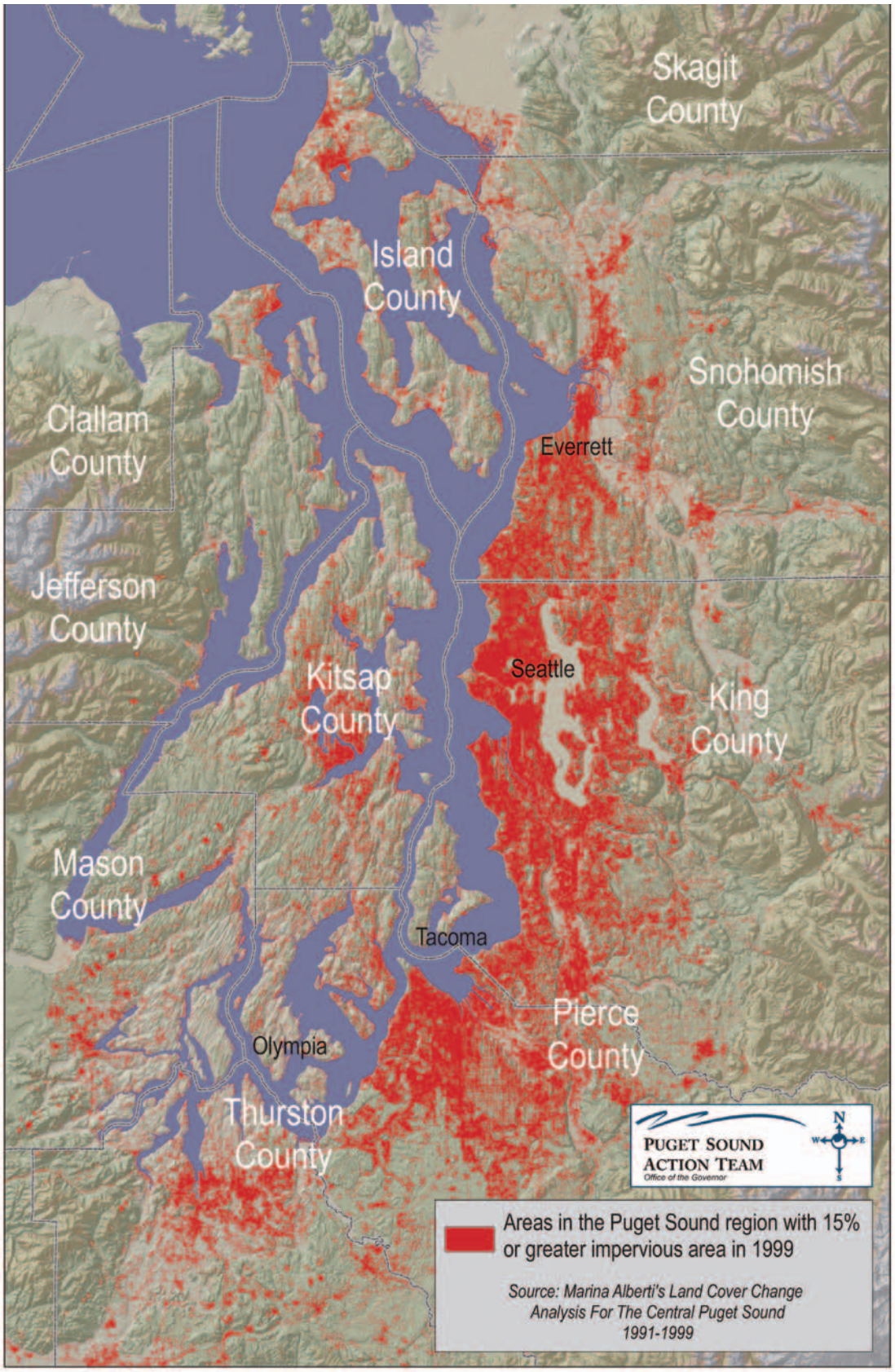


Figure 3.1 indicates the amount and location of impervious surface in the Puget Sound region. Map courtesy the Puget Sound Action Team

Today the cities of Seattle, Everett and Tacoma form a metropolitan area of over three million people along the Interstate 5 corridor. Suburbs and small cities have rapidly filled in the spaces in between, and a complex human-constructed network of roads, bridges, and utilities provide residents with transportation corridors, power, water supply and waste disposal. This system of urban infrastructure has largely displaced the natural network which once sustained salmon habitat throughout the freshwater and nearshore areas of Puget Sound.

Streams in heavily urbanized areas have lost much of their complexity and riparian vegetation. For example, Thornton Creek in the Seattle area lost all of its wetlands and 60% of its open channel network during 100 years of development. The remaining stream system is heavily armored with rock and concrete along its banks, has extensive culverts and pipes, and little native vegetation remains. Despite heavy outplants of salmon into the creek for many years, only a handful of returning adults have been observed in recent years.

When watersheds are urbanized, problems may result simply because structures are placed in the path of natural runoff processes. In almost every point that urbanization activity touches the watershed, sources of pollution occur. Water infiltration is reduced due to an increase in impervious surfaces. As a result, runoff from the watershed is flashier, with increased flood hazard. Flood control and land drainage schemes may concentrate runoff, resulting in increased bank erosion, eventually causing widening and downcutting of the stream channel. Sediments washed from the urban areas contain trace metals such as copper, cadmium, zinc, and lead. These together with pesticides, herbicides, fertilizers, gasoline and other petroleum products, contaminate drainage waters and harm aquatic life necessary for salmon survival (FR 62, 5/6/97).

Wastewater treatment plants contribute additional metals and contaminants such as ammonia, chloride, aluminum, boron, iron, manganese, oil/grease, PCBs and other toxic substances.

"As cities around the Sound grew and prospered, human activities left chemical contaminants buried in the sediments. Pulp mills, chemical factories, smelters, shipyards, oil refineries, and other industries dumped byproducts into the Sound for years before federal and state governments placed controls on such discharges. Most of the contaminated sediments of Puget Sound are found in the nearshore areas of urban bays near Seattle, Tacoma, Bremerton, Everett and other major cities." (Puget Sound Action Team, 2004).

A 1997 study by NOAA and the Washington Department of Ecology indicated that 400,000 acres of the areas tested for sediment in Puget Sound are clean. However, 5,700 acres are highly degraded, and sediments of intermediate quality cover 179,000 acres. This represents an improvement from the 1970's when contaminant levels peaked. The Puget Sound Action Team has indicated that much of the contamination still present in the mud came from historic activities that are now outlawed or controlled by state and federal laws.

Much of the urbanized area in Puget Sound is concentrated near the mouths of rivers and along estuarine shorelines, coinciding with important and sensitive habitat required by salmon. Urban leaders face challenges accommodating the anticipated growth of the region without exacerbating existing habitat deficiencies.

"Our watershed is keenly aware that we have the biggest population center, and the largest recovery challenge."

Jim Compton, Seattle City Councilman

Photo by Dan Kowalski

Nearshore, Estuary and Marine Habitat Modification

An 1885 survey estimated that there were 267 square kilometers of tidal marsh and swamps bordering Puget Sound. Tidelands extended 20 km inland from the shoreline in the Skagit and Stillaguamish watersheds. Approximately 100 years later, only 54.6 km2 of intertidal marine or vegetated habitat is estimated to occur in the Puget Sound basin. This represents a decline of 80 percent across the region due to agricultural and urban modification of the lowland landscape (NMFS/Chum BRT, 1997). In heavily industrialized watersheds, such as the Duwamish, intertidal habitat has been eliminated by 98 percent, (Figure 3.2).

In addition to the high-intensity industrial and urban development at major river mouths in Puget Sound, intertidal and nearshore habitats throughout the Sound have been modified by shoreline armoring (e.g. construction of rock, concrete, and timber bulkheads or retaining walls). These modifications have a cumulative environmental impact that

Estuary	Area (ha)		Change (%)
	Pre-development	Amount in 1970's	
Nooksack	445	460	+3
Lummi	580	30	-95
Samish	190	40	-79
Skagit*	1600	1200	-25
Stillaguamish	300	360	+20
Snohomish	3900	1000	-74
Duwamish	260	4	-98
Puyallup	1000	50	-95
Nisqually	570	410	-28
Skokomish	210	140	-33
Dungeness	50	50	0

*More recent and more encompassing studies of the large scale habitat changes in the Skagit Delta indicate a loss of riverine tidal and estuarine habitat of 72% (Beamer et al., 2003).

Figure 3.2 Changes in Areas of Selected Puget Sound Estuaries from 1800s to 1970s. (from Simestad, et al. 1992 as cited in Upstream)

Forage Fish Spawning Areas

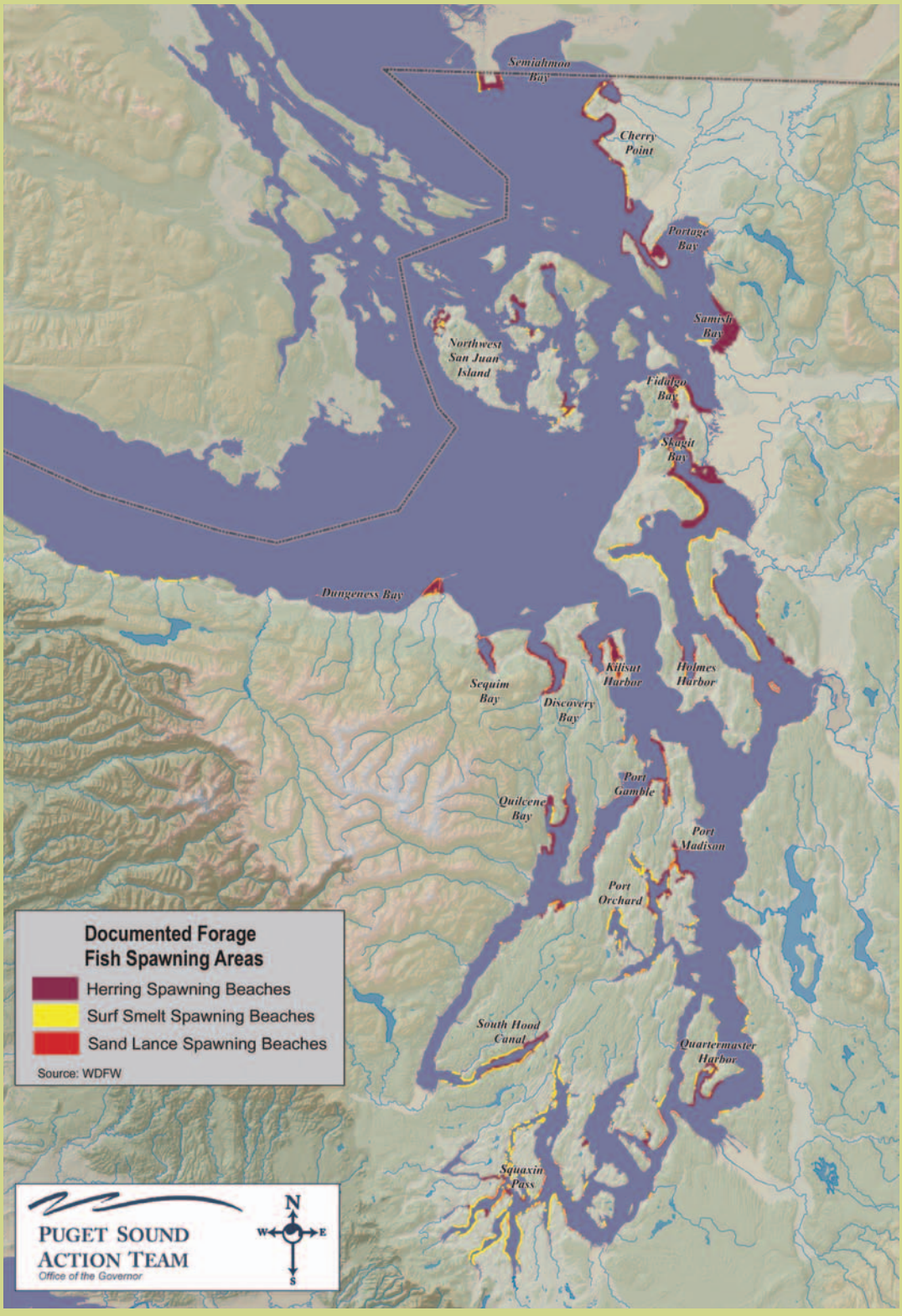


Figure 3.3 indicates Nearshore areas throughout the Puget Sound region that are known forage fish spawning beaches. Forage fish are an important food source for salmon. Map courtesy of the Puget Sound Action Team.

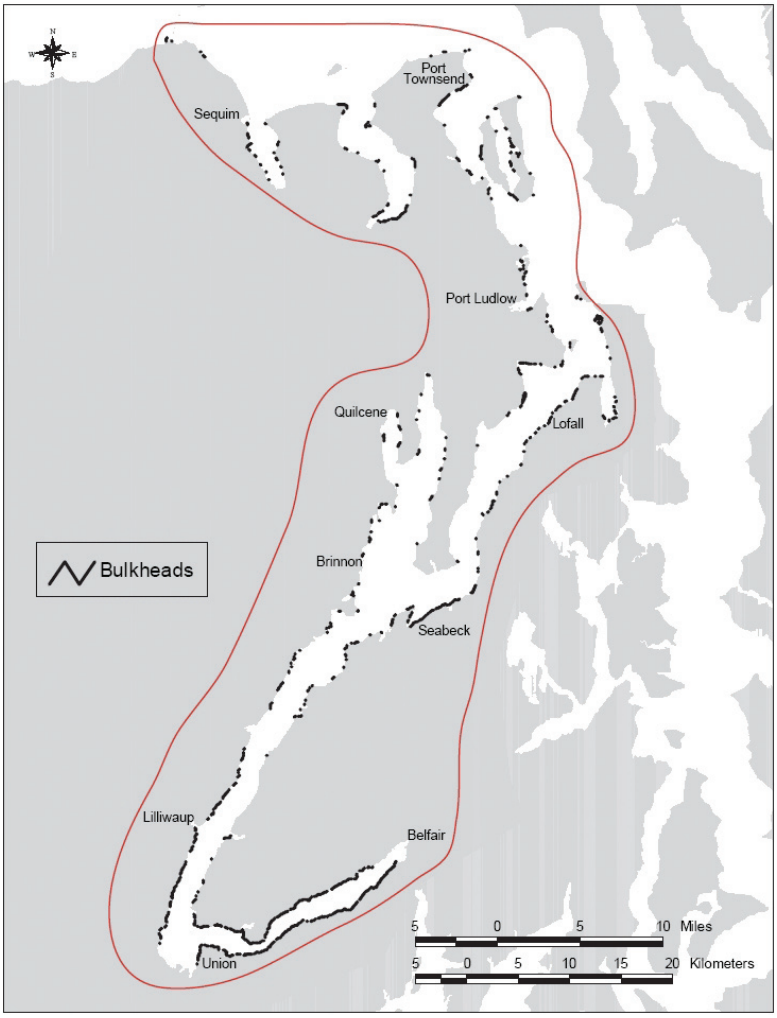


Figure 3.4 shows the distribution of bulkheads throughout the Hood Canal. Map courtesy the Northwest Indian Fisheries Commission, and the Salmon and Steelhead Habitat Inventory and Assessment Program, (SSHIAP).

results in loss of riparian vegetation, obstruction of sediment movement along the shoreline, interference with wave action, and burial of upper beach areas. Although upper beach areas are not utilized directly by salmon, they are egg-laying grounds for species of smaller forage fish that salmon depend on. A 1994 inventory of armoring along Bainbridge Island indicated that between 42% and 67% of the entire shoreline had been armored (NMFS/Chum BRT, 1997). A recent inventory of bulkheads in Hood Canal conducted by the Point No Point Treaty Council demonstrated large clusters of bulkheads throughout the Canal (figure 3.4).

Diking and Floodplain Modification

Extensive dredging, diking and filling for flood control and development beginning in the early 1900s eliminated and degraded miles of salmon habitat. One area hard hit by major floodplain modification was in south Puget Sound where, "The Puyallup, White and Carbon Rivers are all contained within a revetment and levee system for their lower 26, 8 and 5 miles respectively. These channel containment structures have removed the natural sinuosity of the rivers and the spawning and rearing habitats that were once present." (South Sound Salmon Recovery Chapter). Dikes, levees, and channelization beginning in 1906 reduced the length of the Puyallup River from its mouth to the confluence with the White River by 1.84 miles, a loss of almost 15% of its channel length in that section alone. Levee structures eliminated connections with side-channel and off-channel habitat. Although juvenile Chinook fry would once have been present in high numbers in the lower river and its distributaries, the modifications of the floodplain have increased water velocities, making it difficult for juveniles to maintain their position or defend territories. Spawning activity throughout

Cherry Creek, King County. Dikes separate rivers from their historic side channels, wetlands, and floodplains. Photo courtesy the Washington State Salmon Recovery Funding Board.

Modifications and threats to the function of the Puget Sound nearshore and marine environments for salmon include:

33% of Puget Sound Shorelines have been modified with bulkheads or other armoring.

73% of the wetlands in major deltas of Puget Sound rivers have been lost in the last 100 years.

Number of piers and docks in Puget Sound: 3,500

Number of small boat slips: 29,000

Number of large ship slips: 700

Before 1900, 4,000 acres of tidal marshes and mudflats once existed where Harbor Island and the East and West Waterways now stand in Elliott Bay, Seattle.

290 "pocket estuaries" formed by small independent streams and drainages have been identified to occur throughout Puget Sound; of these 75 are stressed by urbanization.

40+ aquatic nuisance species currently infest Puget Sound. In 2003, Spartina species infested 770 solid acres of Puget Sound.

972 municipal and industrial wastewater discharges into the Puget Sound Basin are permitted by the Washington Department of Ecology. 180 permit holders had specific permission to discharge metals, including mercury and copper. Over 1 million pounds of chemicals were discharged to Puget Sound in 2000 by the 20 industrial facilities that reported their releases to the Environmental Protection Agency.

An estimated 500,000 on-site sewage systems are estimated to occur in the Puget Sound basin.

16 major (> 10,000 gallons) spills of oil and hazardous materials occurred in Puget Sound between 1985 and 2001. 191 smaller spills occurred from 1993 to 2001, releasing a total of more than 70,000 gallons.

More than 2,800 acres of Puget Sound's bottom sediments are contaminated to the extent that cleanup is warranted.

Sources for these figures, along with information on the relationship of these threats to salmon, are included in the Nearshore Chapter.

A sample of the changes to the Puget Sound nearshore and marine environment which have occurred over the past 100 years is contained in figure 3.5.

the diked portions of the river is limited, and water velocities scour pockets of eggs. The Puyallup basin represents one of the more extreme examples of floodplain modification in the region, but dikes, channelization and bank armoring are widespread throughout Puget Sound.

Water Diversions and Hydroelectric Development

The growth of towns and industries along Puget Sound created the need for water supply and power to municipal and industrial facilities. The steep drop from the Cascade and Olympic Mountains to sea level in the Puget Sound basin was ideal for the development of dams to impound water supplies and generate hydroelectric power.

Within the Puget Sound region, several major dams block access to historic Chinook salmon spawning and rearing habitat as follows:

Elwha River:
Elwha and Glines Canyon Dams

Green River:
Howard Hansen Dam

Puyallup River:
Electron Dam

White River:
Mud Mountain Dam

Cedar River:
Cedar Falls Dam

Skagit River:
Gorge Falls Dam

Baker River:
Baker Dam

North Fork Skokomish River:
Cushman Dam

Nooksack River:
Middle Fork Diversion Dam

The construction of the Cushman Dam may have isolated a population of Chinook salmon in Lake Cushman, creating a resident population. Passage at Chittendon Locks (Lake Washington) also poses a barrier problem for downstream juvenile Chinook salmon migrants and bull trout.

In addition to the major dams, blockages for water diversion, hatchery water supply, and small hydro development occur on several tributary streams throughout the Sound. While many of these tributary barriers may not block access for Chinook spawning and rearing specifically, they still generate downstream impacts to mainstem river areas by interrupting flow and sediment transport, large woody debris recruitment and transport, nutrient supply, and elevating temperatures.

Physical barriers also alter streamflow which

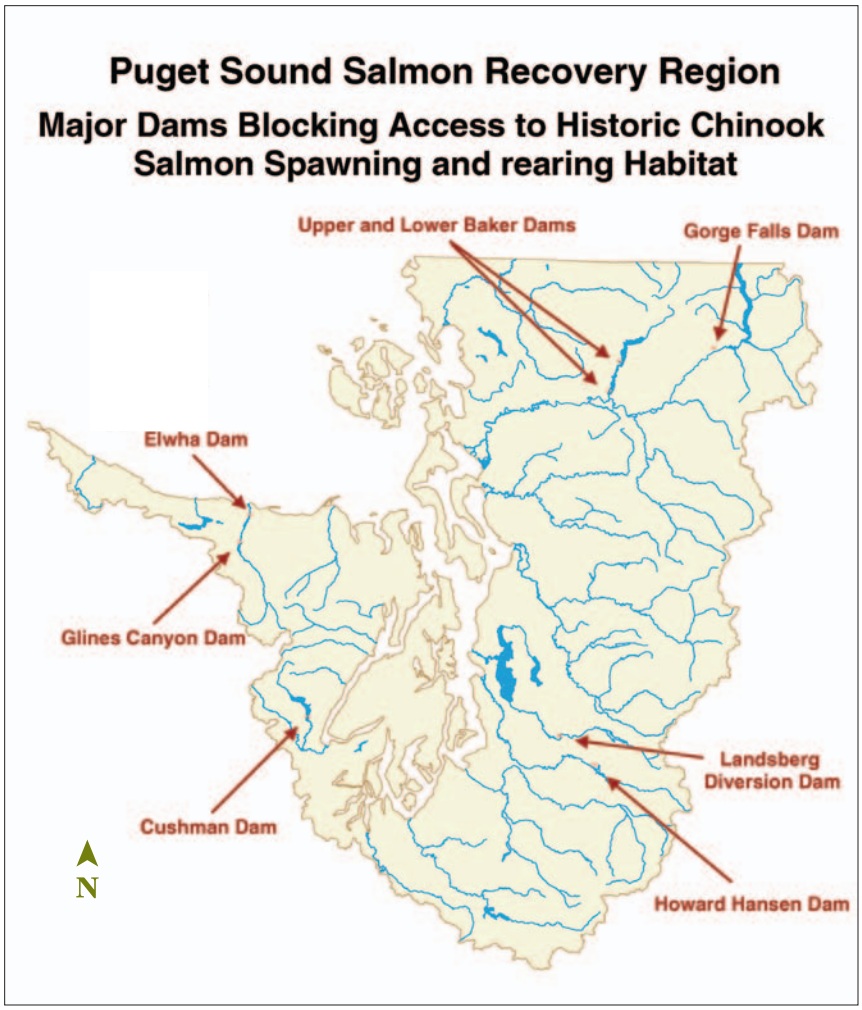


Figure 3.6 illustrates a partial list of the major, human-made chinook passage barriers in the Puget Sound. Map courtesy Washington Department of Fish and Wildlife.

increases salmon mortality in several ways — migration can be delayed by insufficient flows or habitat blockages; loss of usable habitat due to dewatering; stranding of fish resulting from rapid flow fluctuations; and juvenile fish becoming entrained from high velocity waters at poorly screened diversions. Reduced flows also diminish fish habitat by decreasing recruitment of new spawning gravels, and allowing the encroachment of non-native vegetation into spawning and rearing areas.

Dams have also been cited as a major factor affecting bull trout in the Olympic Peninsula and Puget Sound management units. In addition to downstream habitat damage, barriers limit the interaction of populations in core areas, reducing long term genetic viability and eliminating life history forms. Bull trout that migrate downstream of dams without return fish passage are unable to return and contribute to the upstream population. Dams in several locations have formed migratory barriers

The Story of the Elwha River

The Chinook salmon of the Elwha River were well known throughout the Northwest; the rugged canyons and wild waters rushing down from the Olympic Mountains had isolated a race of genetic giants among salmon, commonly weighing over 75-100 pounds. Early settlers envisioned the transformation of the river's energy into power for operating the mills in the nearby city of Port Angeles. Despite laws that prohibited the total blockage of the stream channel, a loophole in the law around 1915 allowed dams to be constructed without fishways, so long as hatcheries were built in lieu of fish ladders (Lichatowich, 1999). In the early years following the construction of the dam, thousands of Chinook returned from sea and beat themselves against the concrete wall in an effort to return to their natal spawning grounds. Descendants of the original population have continued to spawn in the few miles left to them, and have been used as hatchery broodstock. Plans to remove the two dams on the Elwha River and allow Chinook to return to pristine spawning grounds still remaining above the dams in Olympic National Park are well along, and removal is set to begin in 2008.

"A lot of our tribal elders have passed on that put up the fight to get the dams removed. It's going to be a very emotional time when they start taking them down."

Dennis Sullivan, Lower Elwha S'Klallam Tribal Chairman

and isolated populations that were once connected, such as those in the Middle Fork Nooksack, upper and lower Skagit, Puyallup, Elwha, Skokomish and White Rivers. Although information on historic use of upper watersheds by bull trout is incomplete in many locations, it is thought that diversion dams, hydroelectric facilities and pipeline crossings have formed migratory barriers in the Nisqually and lower Green Rivers (USFWS, 2004).

"The Sound might have absorbed some environmental impact 100 years ago, but we have pushed our Puget Sound ecosystem to the limit."

Christine Gregoire, Governor

Habitat Factors Limiting Salmon Production

None of the pioneers and their followers who were drawn to Puget Sound to farm, produce lumber, or build communities and jobs came with the intent of destroying salmon, but incrementally and collectively these activities degraded the habitat and caused long term declines in fish abundance, productivity, spatial distribution and diversity. Some of the change was obvious to the naked eye, as trees were removed, dams built and areas paved. Other changes that affected stream temperatures, water chemistry and the food web for salmon were more insidious. Despite the change, salmon continued to return for generation after generation, but in the late 20th century the collective impacts exceeded their capacity to continually perpetuate themselves.

Loss of Habitat-Forming Processes

Salmon depend on habitat variety to find food and avoid predators — the suite of pools, riffles, boulders, logjams, side channels, wetlands and other features of their rivers; and the saltwater sloughs, marshes, eelgrass and kelp beds in the marine environment. The simplification of habitat features caused by vegetation removal and construction along streambanks and shorelines has had a pervasive and cumulative effect. The structural diversity that enabled salmon to thrive was built over centuries by the complex interaction of light, water, soil, vegetation and nutrient cycles. Salmon evolved to stream conditions that had cyclical disturbances varying by days, decades and centuries. Human activities modified these constant cycles of change by increasing the frequency of disturbance, altering the magnitude of disruption, and affecting the ability of the stream channel to respond.

Most devastating to the long term viability of salmon has been the modification of the fundamental natural processes which allowed habitat to form, and recover from disturbances such as floods, landslides, and droughts. So critical are these driving processes that Spence et al. (1996) state that " ...salmonid conservation can be achieved only by maintaining and restoring these processes and their natural rates." Among the physical and chemical processes basic to habitat formation and salmon persistence are floods and droughts, sediment transport, heat and light, nutrient cycling, water chemistry, woody debris recruitment and floodplain structure. Important biological processes that depend on habitat dynamics include migration, adaptation, the complex energy transfers of the food chain, and the metabolism of the fish.

Vegetation removal has also altered the hydrologic system in many watersheds, affecting the watershed's retention of moisture and increasing the magnitude and frequency of peak and low flows. Wetlands play an important role in hydrologic processes, as they store water which ameliorates high and low flows. The interchange of surface and groundwater in complex stream and wetland systems helps to moderate stream temperatures. Forest wetlands are estimated to have diminished by one-third in Washington State. (Spence et al., 1996; FEMAT, 1993)

Despite the improvement in timber practices, many long lasting effects from timber harvest continue to degrade aquatic habitat. Surface erosion and slope failure from logging roads are an ongoing

Land Use Activity	Habitat-Forming Processes						
	Vegetation / Organic matter	Hydrology	Thermal Regime (temperature/ light)	Soils	Nutrients	Chemical Composition	Riparian Function and Floodplain Dynamics
Forestry	Timber harvest removes the forest canopy, changes the composition of tree species, and modifies the type and rate of input of leaves and other organic matter into streams, thereby affecting the food supply for salmon.	Vegetation removal alters the water storage capability of the watershed, changes the timing of runoff, and may increase the magnitude and frequency of peak flows and low flows. Peak flows may scour redds and cause mortality to juveniles. Low flows limit spawning and migration.	Summer stream temperatures are documented to increase by 3-8°C following clearcutting and up to 16°C in small watersheds, and may take many years to recover. High temperatures stress salmon and in extreme cases can cause mortality.	Mass failures may result from road construction or vegetation removal on unstable slopes. Surface erosion from bare soil also changes the rate of soil input to a river system. Soil compaction results from equipment use during harvest. Soil transfer alters availability of spawning gravel. Fine sediments can severely impact eggs and juveniles.	Vegetation removal leads to a loss or reduction of the nutrient supply and changes the normal rate of decomposition and input of nutrients.	Use of fertilizers herbicides, pesticides and other chemicals alters water chemistry and some substances are toxic to salmon, resulting in direct mortality, reducing resistance to disease, or ability to reproduce.	Timber harvest removes the large woody debris that provides structure for stream channel features such as pools and riffles.
Agriculture	Conversion of woodlands and wetlands removes riparian vegetation.	Forest clearing alters soil retention of water, which is further exacerbated by ditching and draining to create crop lands. Runoff timing and patterns are altered. Irrigation directly removes instream flows, affecting the availability of spawning and rearing habitat.	Loss of shade along riparian corridor increases stream temperatures as do return flows from irrigation. Low flows, sedimentation and nutrient input further exacerbate temperature problems.	Agricultural crop practices may increase surface erosion with substantial sediment input into streams.	Runoff from animal waste and other farm activities increases the nutrient load and depletes the oxygen available for salmon	Use of fertilizers, herbicides and pesticides alter the water chemistry and may result in direct mortalities or the alteration of physical condition of salmon.	To create and protect agric. lands, stream channels have been straightened and banks have been armored removing low velocity side channels. Diking of estuarine sloughs has removed the quantity and quality of lower river rearing habitat.
Urbanization	Severe, permanent alteration of vegetation.	Impermeable surfaces create permanent loss of water infiltration to soil and stormwater runoff is rapid and severe. Water withdrawals for urban and industrial supplies deplete instream flow.	Loss of shade increases summer maximum and may decrease winter minimum stream temperatures. Disruption of groundwater input will reduce its moderating effects on stream temperatures.	Construction activities create intensive short term sediment input.	Loss of leaf matter from vegetation is replaced with nutrient input from sewage, fertilizers and other sources.	Stormwater runoff includes oils, pesticides, metals and other toxic substances.	Permanent severe alteration of meandering stream channel and wetland structures. Bank hardening, fill and dikes remove other habitat features. Dikes isolate or fragment habitat and increase stream velocity.

Figure 3.7 Relationship of forestry, agricultural and urban land use activities to habitat processes affecting salmon.*

* A more complete discussion of these relationships including other land use activities is contained in "An Ecosystem Approach to Salmonid Conservation" also known as the "Man Tech" report by Spence, et al. 1996. Additional discussion of applying information on habitat characteristics to recovery planning is contained in, "Ecosystem Recovery Planning for Listed Salmon: An Integrated Assessment Approach for Salmon Habitat" by Beechie, et al., 2003.

Figure 3.7 outlines the ways that some of the major land use activities in the Pacific Northwest have modified the fundamental and interlinking processes that form salmon habitat. One of the major factors affecting habitat has been the temporary and permanent removal of vegetation. Vegetation is a key component of the light and temperature regimes in stream systems. The logging, farming and development activities described previously removed streamside vegetation, resulting in long term increases in water temperatures and drastically affecting the ability of bull trout and salmon to survive. Summer stream temperatures have been documented to increase by 3 to 8°C (5.4 -14.4°F) following clearcutting and up to 16oC (28.8°F) in small watersheds (Spence, et al., 1996). High temperatures may stress or kill salmon outright, or limit the production of organisms they need for food. Water temperatures above the tolerance threshold for Chinook migration, rearing or emergence have been found in the Nooksack, Dungeness, Elwha, Green/Duwamish, Skagit, Snohomish and Stillaguamish Rivers.

Poor riparian conditions can result in higher water temperatures which may stress or kill salmon. Photo courtesy the Washington State Salmon Recovery Funding Board.

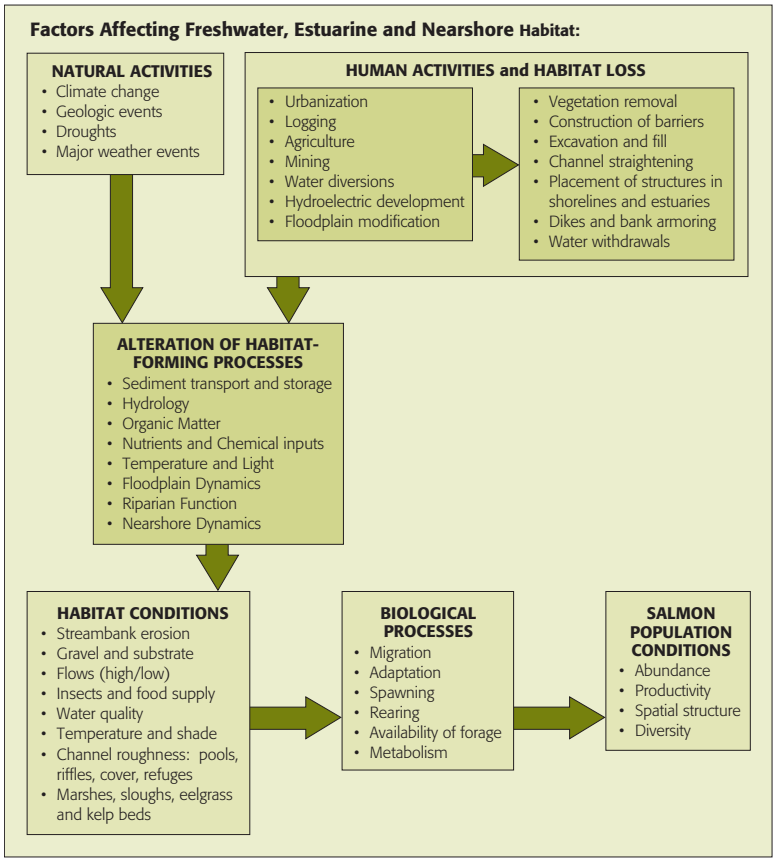


Figure 3.8

source of fine sediment and debris, with detrimental effects to salmon habitat. (Spence, et al., 1996; National Research Council, 1996) Sedimentation filled in many of the large deep pools in rivers and many river systems have been unable to recreate these essential habitat features for salmon, since the large wood that would serve as the structural raw material has been removed. Sediment input also results from urban construction and agricultural practices and the excessive input of fine sediments has been identified as a problem in every watershed into Puget Sound.

The toxic mix of oil, grease, pesticides and other pollutants carried by stormwater runoff alters the chemical processes of urban streams and creates dramatic shifts in their flow patterns. Recent studies by NMFS and the Seattle Public Utilities have also documented high rates of outright mortality to adult salmon still full of eggs and sperm, even in a creek where habitat had been restored. While the restoration of these urban creeks is essential to allowing greater numbers to spawn, the studies suggest that the control of polluted runoff from urban streets, lawns and parks and restoration of chemical balance is imperative to fish productivity (Scholtz, 2003).

Riparian function depends on vegetated banks, and the removal of large trees precludes the recruitment of large woody debris, essential to a varied channel structure. Dikes and levees generally have maintenance requirements that prohibit vegetation, largely eliminating the production of food for salmon and the recruitment of large woody debris for cover and diverse channel structure. Channelization and floodplain structures such as dikes reduce river sinuosity, increasing water velocity and reducing the volume of habitat. In many cases, floodplain structures eliminate the connection to side channels and wetland complexes where salmon once could rest and feed.

Guidelines for salmon recovery emphasize the need to address fundamental ecosystem processes by restoring vegetation, hydrology, channel structure and essential food supplies for salmon.

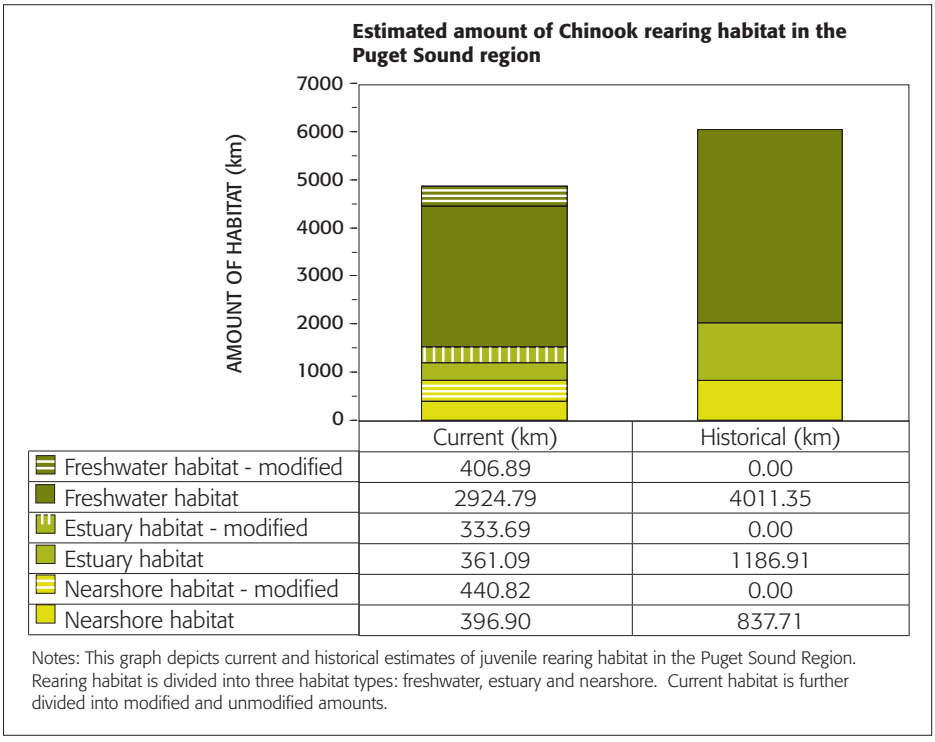
"Salmon are adapted to local environmental conditions....[that] vary in space and time due to landscape processes and land use. Because landscape processes (e.g., sediment supply, wood recruitment to streams) create and sustain habitats over time, an approach to habitat recovery that focuses on preserving or restoring ecosystem processes should provide good quality salmon habitat over the long term." (Beechie, et al.; 2003)

Technical Assessments of the Potential to Recover Chinook populations at the ESU Scale

Several "broad-brush" looks at habitat conditions in the entire Puget Sound ESU indicate that the potential capacity of watersheds to support Chinook spawning and rearing is still present in many watersheds. Coarse scale assessments of this nature are unable to factor in the varying levels of detail that have gone into habitat analysis in each watershed. Some watersheds have been able to assemble the resources to conduct studies of habitat factors in more depth than others. Additionally, the Sound-wide review has so far focused primarily on the quantity of potential habitat, and generally has yet to fully incorporate qualitative information. The individual watershed plans submitted in the Spring of 2005 contain a large amount of habitat information that will need to be assimilated into an ESU-wide assessment of habitat and its effect on VSP parameters.

Figure 3.9 contains a map depicting current and historical spawning capacity for Puget Sound Chinook populations, to display the varying levels throughout the Sound. Several watersheds still retain habitat with the potential to support spawning at historical capacity levels, although the quality may have been modified by flow diversions and other impairments. The Elwha River represents the opposite case, as it has lost approximately 85% of historical spawning capacity, but the quality of habitat above the dams has been fully retained since these areas are located in Olympic National Park. Dam removal, scheduled to begin in 2008, will restore access to these spawning areas.

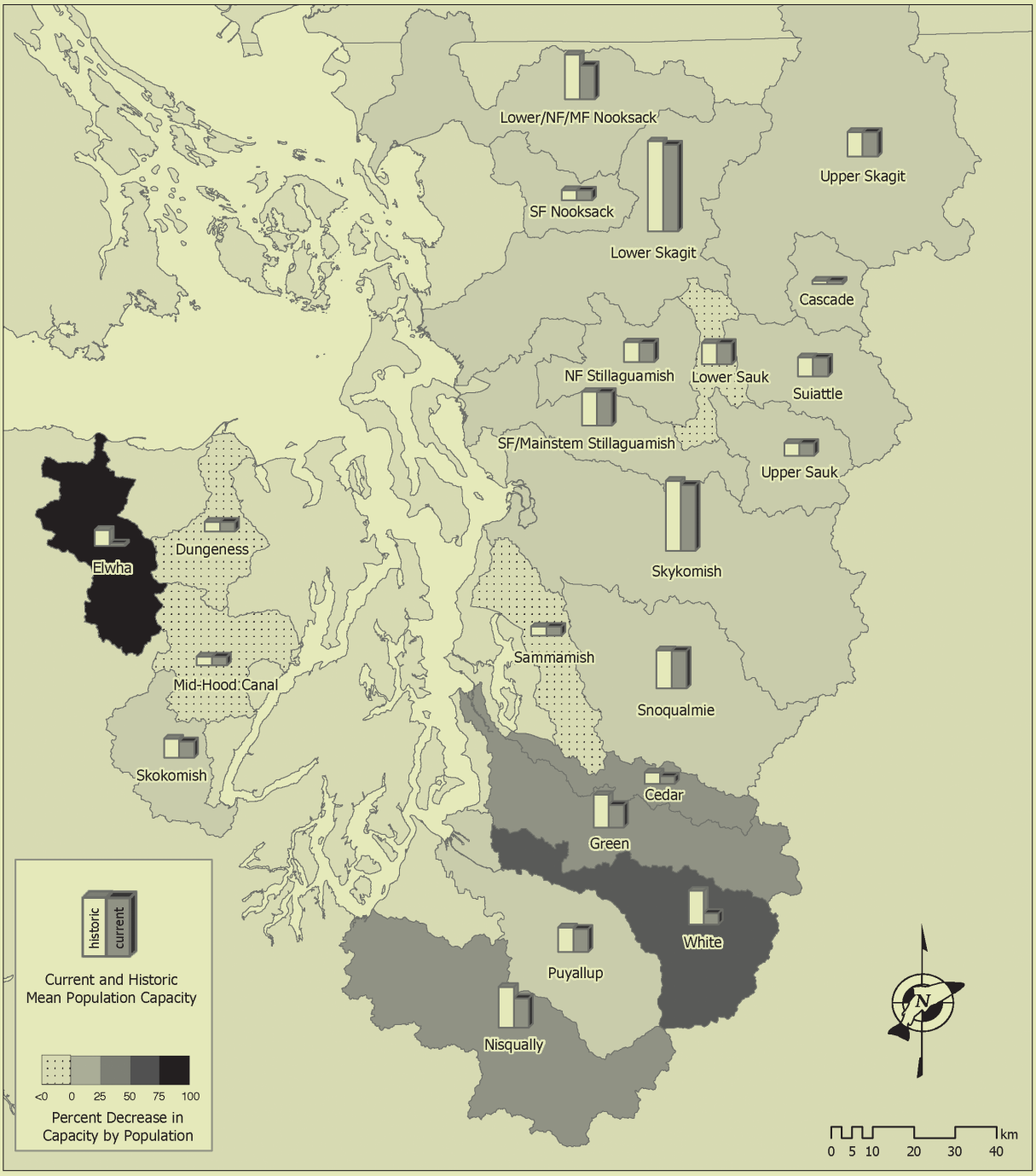
In addition to spawning capacity, NOAA Scientists have begun to collectively estimate changes in the amount of freshwater, estuary and nearshore rearing habitat in the Puget Sound region. Through airphotos, map layers and historical reports covering wetlands, vegetation and stream channel locations, rough estimates can be made of the amount



	Current (km)	Historical (km)
Freshwater habitat - modified	406.89	0.00
Freshwater habitat	2924.79	4011.35
Estuary habitat - modified	333.69	0.00
Estuary habitat	361.09	1186.91
Nearshore habitat - modified	440.82	0.00
Nearshore habitat	396.90	837.71

Notes: This graph depicts current and historical estimates of juvenile rearing habitat in the Puget Sound Region. Rearing habitat is divided into three habitat types: freshwater, estuary and nearshore. Current habitat is further divided into modified and unmodified amounts.

Figure 3.10 Courtesy NOAA Fisheries, NW Fisheries Science Center; M. Ruckelshaus



Historical Population Capacity Changes of Adult Chinook in Puget Sound ESU

Chinook Potential Spawning Capacity Estimates and Percent Decrease by Population

Population	Mean Capacity		% Decrease	Population	Mean Capacity		% Decrease
	Historic	Current			Historic	Current	
Lower/NF/MF Nooksack	62,027	47,046	24.2	Snoqualmie	52,525	51,828	1.3
SF Nooksack	13,648	13,392	1.9	Sammamish	12,406	12,468	0
Lower Skagit	124,563	119,786	3.8	Cedar	15,086	10,076	33.2
Upper Skagit	33,684	33,286	1.2	Green	45,247	31,419	30.6
Lower Sauk	29,437	29,378	0.2	White	46,232	15,601	66.3
Cascade	4,030	3,961	1.7	Puyallup	33,900	31,745	6.4
Suiattle	25,958	25,672	1.1	Nisqually	56,500	40,898	27.6
Upper Sauk	17,512	17,340	1	Skokomish	26,008	22,546	13.3
NF Stillaguamish	27,195	26,821	1.4	Mid-Hood Canal	12,166	12,288	0
SF/Mainstem Stillaguamish	46,108	45,837	0.6	Dungeness	12,852	12,912	0
Skykomish	96,501	91,279	5.4	Elwha	21,617	3,318	84.7

Figure 3.9 Courtesy NOAA Fisheries, NW Fisheries Science Center; M. Ruckelshaus

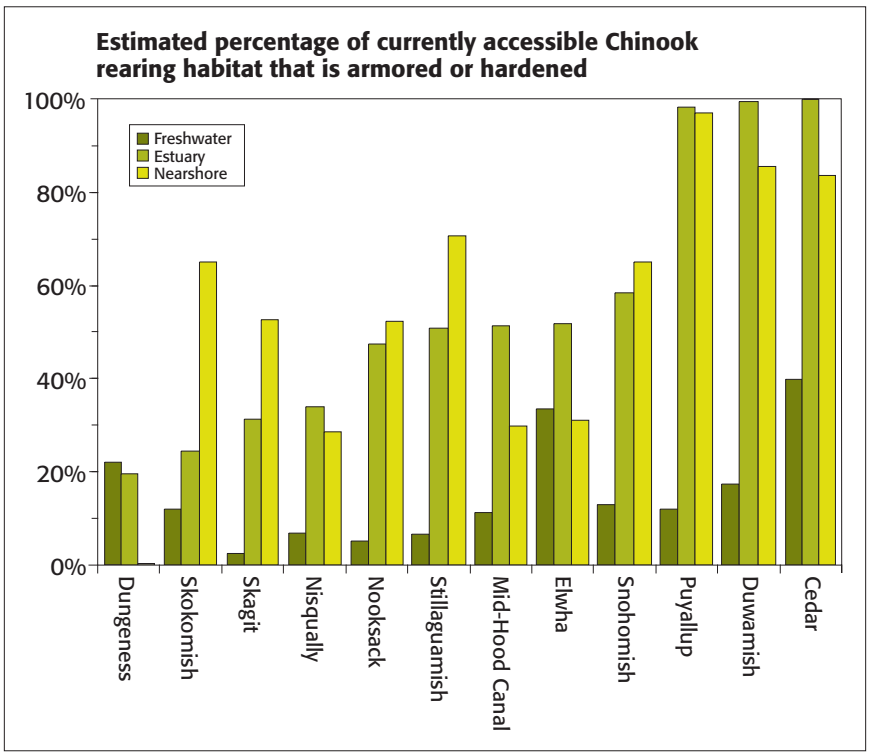


Figure 3.11 Courtesy NOAA Fisheries, NW Fisheries Science Center; M. Ruckelshaus

of Chinook rearing habitat in the region and the proportion that has been modified (figure 3.10). These estimates indicate that large quantities of juvenile rearing habitat remain relatively unmodified in portions of Puget Sound, and the connectivity and protection of these ecosystem features should be a focus for future study and action.

Additional analysis has been made of the percentage of bank armoring or hardening that has occurred in freshwater, estuary and nearshore environments. The extent of modification varies around the Sound, with extensive bank armoring or hardening in most of the river basins in South Puget Sound.

Studies such as these are assisting scientists with assessing the potential for improvements in VSP parameters at the scale of the entire Puget Sound Chinook ESU. This is particularly true for the spatial distribution and diversity parameters in the ESU since these will require a broader look than is possible watershed by watershed.

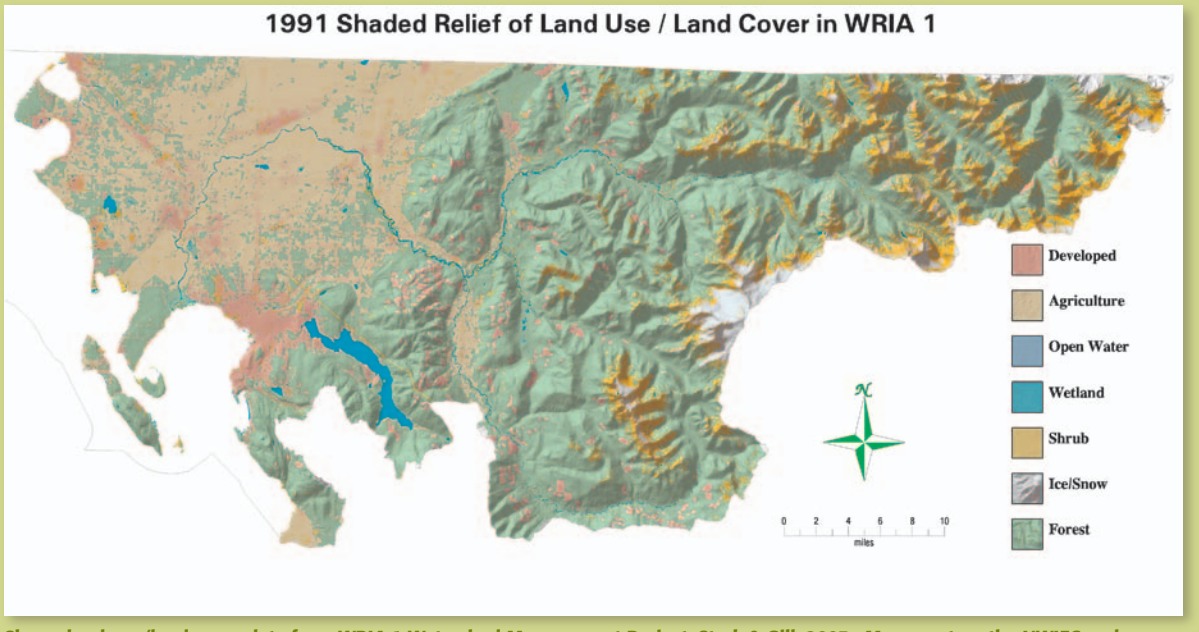
Technical Assessments of Habitat Factors at the Watershed Scale

Detailed technical analyses of the habitat factors affecting Puget Sound Chinook and other fish species are contained in the following reports and spatial information:

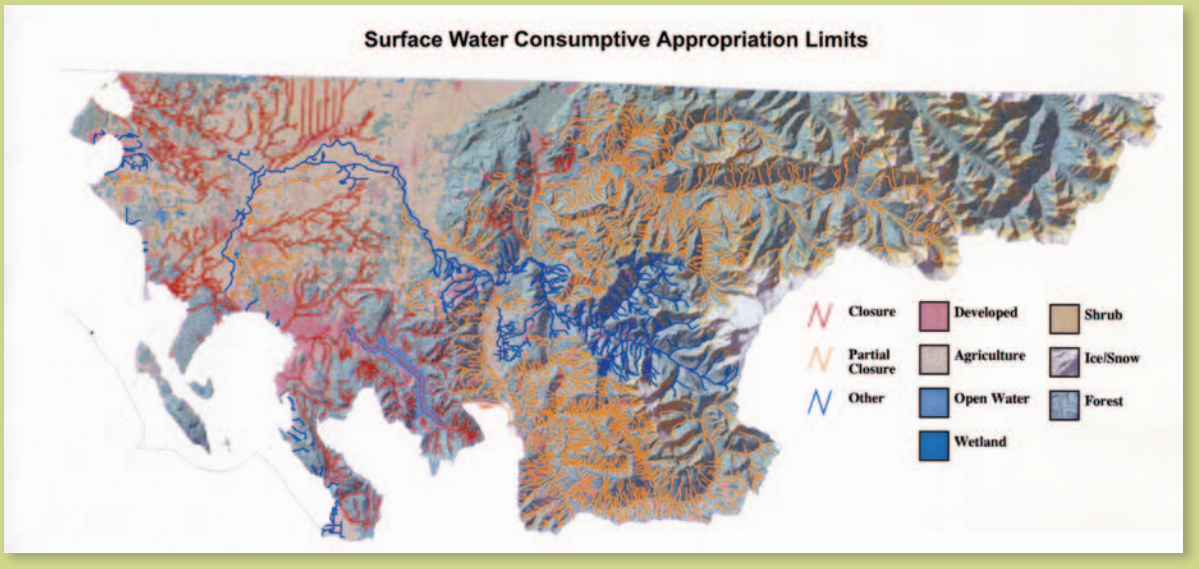
Salmon and Steelhead Habitat Inventory and Assessment Program: Since 1995, this cooperative project between the Northwest Indian Fisheries Commission and WDFW has characterized salmon habitat conditions and the distribution of salmonid stocks in Washington. The spatial data system is designed to utilize comprehensive, consistent data with sophisticated analytical tools to provide a variety of digital products and maps for regulatory and conservation efforts related to salmon in Washington. For each basin SSHIAP has information such as:

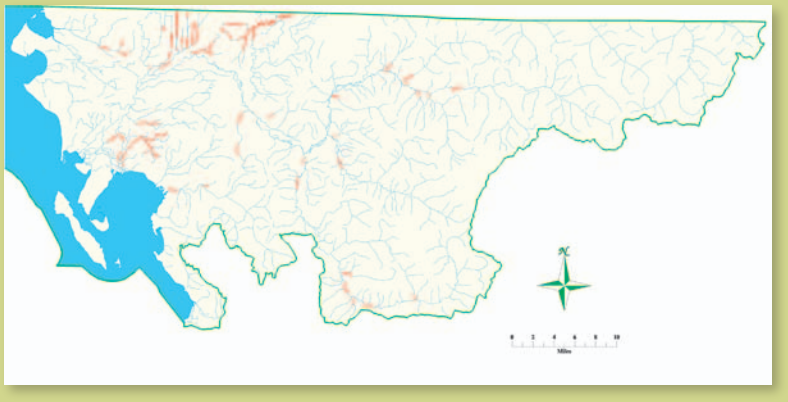
- Basin summary
- Land use relief map
- Escapement levels and stock status
- Limiting factors summary
- Map and list of impaired water bodies from the Clean Water Act 303(d)
- Surface water appropriation status
- Man-made blockages
- SRFB projects implemented

The SSHIAP program information is available on the website of the Northwest Indian Fisheries Commission [www.nwifc.org]. A sample of the products that are available through the SSHIAP program for the Nooksack basin are contained on the following pages.



Shows land use/land cover data from WRIA 1 Watershed Management Project, Stark & Gill, 2003. Map courtesy the NWIFC and Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP).





ABOVE: This map indicating Surface Water Consumptive Appropriation Limits does not include the status for the northward flowing Fraser Drainages (i.e. Sumas and Chilliwack Rivers). Map courtesy the NWIFC and Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP).

AT LEFT: Water courses shown in red denote streams identified in the WA Dept. of Ecology (DOE) 1998 303d listing. Water courses shown in blue are from WA DOE and are shown for locational purposes only. Map courtesy the NWIFC and Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP).

Figure 3.12 A sample of the products that are available through the SSHIAP program.

Habitat Limiting Factors		
Sub-basin/Habitat Area	**Major Limiting Factors**	**Potential Causes**
South Fork	High temperatures; lack of lwd; high coarse and fine sediment load; channel instability; migration passage barriers; loss of wetlands and off channel habitat; loss of channel migration opportunities; low instream flow	Lack of riparian shade and lwd recruitment potential; elevated mass wasting rates; bank hardening; drained wetlands for agriculture; hydromodified channel; impassable culverts; over allocation of water rights; flood control
Middle Fork	Blocked access at rm 7.2; Channel instability; lack of lwd; high course and fine sediment load; high temperatures; lack of instream flow	Diversion dam; lack of riparian shade and lwd recruitment potential; elevated mass wasting rates; bank hardening; impassable culverts
North Fork	Channel instability; lack of lwd; high course and fine sediment load; lack of instream flow; loss of off-channel habitats in historic channel migration areas; high temperatures; blocked access; inadequate instream flow	Lack of riparian shade and lwd recruitment potential, elevated mass wasting; bank hardening including for sr 542 which is located in cmz; impassable culverts; over allocation of water rights
Mainstem Nooksack and Tributaries	Loss of channel migration and off-channel habitats in historic channel migration area; hydromodified channel; lack of lwd; high temperatures; blocking culverts; loss of historic wetlands; over-allocation of water rights; loss of former distributary habitats in estuary, tributary dredging for flood control	Levees and rip-rap and riparian maintenance for flood control; inadequate lwd recruitment potential and riparian shade along mainstem and tributaries, drainage of historic wetlands to promote agriculture; blocking culverts, over-allocation of water rights
Independent Drainages (Dakota, California, Terrell, Squalicum, Whatcom, Padden, Chuckanut, Olyster, and Colony)	Water quality; inadequate stream flows; peak flow impacts; migration passage barriers; high temperatures; loss of wetlands	Over allocation of water rights; increased impervious surface from development; urban storm water run-off; lack of shade and lwd recruitment in riparian zones; blocking tide-gates; flood control
Estuary and Nearshore	Loss of nearshore habitats; disrupted beach nourishment processes important for forage fish spawning; toxic contaminants; altered juvenile salmon migration paths; lost access in former distributaries and pocket estuaries	Filling to promote development; shoreline modifications including rip-rap bulkheads, jetties, railroad located in former nearshore area; industrial pollutants (Bellingham, Cherry Point, etc.); Overwater structures including docks, urban stormwater runoff, blocking culverts and tidegates
Sumas River and Tributaries	Blocked access, inadequate stream flow; high temperatures, inadequate lwd; agricultural runoff including siltation	Flood control along vedder canal and frasier river interrupts migration (Canada), inadequate riparian shade and lwd recruitment potential; drainage of historic wetlands to promote agriculture, dredging for flood control; over-allocation of water rights, blocking culverts

Figure 3.13 Habitat limiting factors for the Nooksack basin, available through the SSHIAP program

Limiting Factors Analyses: The Salmon Recovery Planning Act (ESHB 2496) was passed in 1998. Among other elements, the Act directed the Washington State Conservation Commission to prepare a Limiting Factors Analysis (LFA) for each Water Resource Inventory Area in Washington State. A technical advisory group was formed for each area consisting of state and tribal fisheries biologists and other local experts to evaluate habitat factors including barriers to migration, and the condition of estuarine areas, riparian corridors, stream channels and wetlands. The LFAs were intended as a basis for prioritizing recovery efforts and for measuring the results of future recovery actions.

The Limiting Factors reports provide considerable detail regarding the habitat factors limiting Puget Sound salmon and steelhead. For each major river and tributary, the reports describe the status of the habitat processes affecting salmon such as loss of access to spawning and rearing habitats, floodplain conditions, streambed sediment, riparian conditions, water quality and quantity problems, and estuarine and nearshore habitat. These reports may be accessed at the Washington Conservation Commission website [http://salmon.scc.wa.gov/].

Watershed Chapters: Shared Strategy watershed planning staff interviewed watershed participants in 2002-2003 to identify the major limiting factors in each watershed. A number of habitat factors were listed as common problems throughout almost all Puget Sound watersheds, such as altered hydrology and sediment transport, water quality degradation, loss of riparian vegetation, lack of large woody debris, and impaired floodplain processes. Additionally the loss of nearshore/estuarine habitat has been identified as a limiting factor throughout

most of the Sound. More studies and information on the habitat conditions in each watershed planning area are located in the watershed chapters.

Ongoing Conservation Measures in the Puget Sound Region

State Statutory and Regulatory Framework

In 1997 a Joint Natural Resource Cabinet was brought together by Governor Gary Locke to coordinate salmon recovery efforts at the state level. The JNRC released the, "Statewide Strategy to Recover Salmon: Extinction is Not an Option" in 1999 which was designed as the state's long term guide for salmon recovery. As noted in the Strategy, many laws exist that directly or indirectly attempt to protect or restore salmon, but, "the troubling status of these fish is an indication that our existing regulatory framework and implementing agencies have been unable to protect salmon populations and their ecosystems." (JNRC, 1999). The regulatory framework includes laws dealing with land and water use and development, laws pertinent to fish and wildlife protection, and three new laws enacted in Washington State in 1998-9 which were specifically directed to bolster the statutory framework for salmon recovery.

Land and Water Use and Development: State laws include the State Environmental Policy Act, Shoreline Management Act, Growth Management Act, Floodplain Management Act, Forest Practices Act, Water Pollution Control Act, Hydraulic Project Approval, Aquatic Lands Act, and the Water Code and Water Resources Act.

Fish and Wildlife Protection: Of the state laws noted above, the State Environmental Policy Act,

Smolt trap on Stimson Creek, created by the Hood Canal Salmon Enhancement Group with funding from the Washington State Salmon Recovery Funding Board. Photo courtesy the Washington State Salmon Recovery Funding Board.

the Growth Management Act, and the Hydraulic Project Approval laws contain provisions relating directly to fish and wildlife protection.

Recent Legislation Directly Related to Salmon Recovery: Three laws were enacted in Washington State in 1998-1999 designed specifically to improve conditions for salmon. The acts recognized the need for comprehensive, coordinated solutions that would be locally based and implemented.

- Salmon Recovery Planning Act (ESHB 2496): This 1998 act provided the framework for developing salmon restoration projects. The Act required the preparation of a limiting factors analysis for habitat, and established the funding mechanism for local restoration projects. The Act also created the Governor's Salmon Recovery Office and an Independent Science Panel to work toward salmon recovery plans for the region.
- Watershed Planning Act (ESHB 2514): Also passed in 1998, this legislation encourages voluntary planning by local governments, citizens, and tribes for water supply and use, water quality, and habitat at the Water Resource Inventory Area level. The Act made available grants for assessments of water resources and preparation of water management plans.
- Salmon Recovery Funding Act (2E2SSB 5595): Adopted the following year, this legislation further developed concepts established in ESHB 2496. The Act created the Salmon Recovery Funding Board to coordinate the allocation of funding for restoration projects across the region, and clarified the content for the statewide strategy to recovery salmon.

Local involvement in identifying solutions for salmon recovery at the watershed level was a fundamental principle of all three laws. Water resource planning under ESHB 2514 identified "initiating governments" at the local level to direct watershed planning activities. The salmon recovery acts encouraged the formation of local "Lead Entity Groups" with citizen sub-committees and technical advisors to evaluate and prioritize restoration and protection projects for each watershed area. These locally-driven efforts were intended to allow local knowledge and relationships to assist planning and implementation, and to account for the differences between urban and rural communities and habitat conditions throughout the state.

As required by the Salmon Recovery Planning Act, the Governor's Salmon Recovery Office has issued a "State of the Salmon in Watersheds" report for 2004 providing an overview of the status of salmon in Washington State, and information on progress toward restoration and protection in the last few years.

Linkage to Federal Actions and Initiatives

Two federal services have direct responsibilities for recovery planning and enforcement of the Endangered Species Act. The National Marine Fisheries Service (NMFS) is charged with overseeing the preparation of recovery plans and rules for threatened and endangered species of West Coast salmon. The US Fish and Wildlife Service (USFWS) has recovery oversight for bull trout. Both agencies have worked closely with tribal, state and local governments and watershed groups in recovery planning for the Puget Sound region. Section 7 of the Endangered Species Act requires that federal agencies consult with NMFS or the USFWS on activities they authorize, fund, or carry out to ensure they are not likely to jeopardize the continued existence of listed species or result in the destruction or modification or their critical habitat.

Related Federal legislation includes the National Environmental Policy Act, Clean Water Act, Federal Reclamation Act, Coastal Zone Management Act, Rivers and Harbors Act, Wild and Scenic Rivers Act and more. Additionally, federal laws such as the Fish and Wildlife Coordination Act, Magnuson-Stevens Fishery Conservation Act, the Marine Mammal Protection Act, and the Pacific Salmon Treaty directly affect recovery processes.

Other major federal actions and initiatives that relate closely to Puget Sound salmon and bull trout recovery planning include the following:

- The Federal Forest Plan was issued by President Clinton and Vice-President Gore in 1993 to guide timber management in the National Forest System in the Pacific Northwest. The related report by the Federal Ecosystem Management and Assessment Team included an aquatic ecosystem assessment chapter identifying at-risk stocks of anadromous fish in the region, key watersheds in the protection of threatened species, and standards for riparian reserves and other forest management parameters. Additionally, the US Forest Service conducts ongoing aquatic habitat monitoring and fish surveys, and is closely involved in restoration of habitat for aquatic and upland species in the Puget Sound region. (FEMAT, 1993)
- The Puget Sound Nearshore Ecosystem Restoration Project began with a reconnaissance study in 2000 conducted by the US Army Corps of Engineers, which concluded that major human modifications along the Puget Sound shoreline have resulted in a significant loss of estuarine and nearshore habitats (USACOE and WDFW, 2001). The study identified a number of actions to restore nearshore habitats to a more natural state. The Puget Sound Nearshore Ecosystem Restoration Project has been undergoing feasibility and study since 2001, and project engineering and design is projected to begin by 2006, with construction targeted for 2009. A companion Corps of Engineers construction authority, the Puget Sound and Adjacent Waters Initiative, was authorized in 2003 for construction of early action restoration projects.
- Several Federal agencies including the Environmental Protection Agency and the US Army Corps of Engineers are closely involved in the cleanup of toxic contamination in Com-

Since 2000, the Salmon Recovery Funding Board has awarded $195.4 million in grants for 592 projects in 30 of the 39 counties in Washington State.

Projects funded by the board include:

• Fixed or removed 132 barriers to fish migration, opening up an estimated 456 miles of stream for salmon habitat.

• Planted trees and shrubs along 96 miles of streams to cool the water and provide sources of wood that can fall into the stream and improve channel structure for salmon habitat.

• Abandoned or fixed 222 miles of road to reduce the amount of soil washing into streams.

• Changed river flows in 85 acres to slow the rivers and create places for salmon to spawn and grow.

• Worked with willing landowners statewide to protect habitat through conservation easements and property acquisitions.

• Removed 19 dikes and tide gates in estuaries to allow freshwater and saltwater to mix, opening an estimated 6 miles of transition areas for salmon headed to and from the sea.

Additional activities funded by the board include:

• Assessments such as an inventory of barriers to fish passage.

• Operation of local salmon recovery boards for recovery planning.

• Support of state agency efforts to improve instream flows and enforce provisions of the "Forest and Fish Agreement"

• Provide technical assistance to family forest landowners.

(SRFB website-home page)

Brian Cladoosby, Chair of the Swinomish Tribe, speaks to a group of tribal members and farmers at a Skagit Tribal/Agricultural Alliance picnic in the summer of 2004.

mencement, Elliott, and Bellingham Bays which include designated superfund sites.

- A number of Puget Sound rivers and tributaries are included on the Environmental Protection Agency's list of impaired water bodies under Section 303(d) of the Clean Water Act for temperature, flows, fecal coliform and other pollutants. The authority for the development of water quality cleanup plans and coastal zone management activities has generally been delegated to the Washington Department of Ecology. The full list is located on the Washington Department of Ecology website.

Transition to Conservation and Restoration by the Local Community

In each of the case studies described in section 4.1.1, local and regional community members have stepped forward within the last two decades to initiate projects and reforms that have slowed the momentum of degradation and placed Puget Sound watersheds on a path toward recovery. After considerable conflict, forest industry representatives and fisheries interests forged a "Forest and Fish Agreement" and prepared a package of regulations for forest practices that provide more protections for aquatic organisms. Farmers in the Dungeness have won state and national awards for their voluntary water conservation efforts that have greatly improved instream flows in the late summer. Similarly, Nooksack basin farmers have instituted many improvements to their farm practices to remediate the water quality and temperature problems documented in the river and tributaries. Recently, farmers in the Skagit Valley met with Swinomish and Sauk-Suiattle tribal leaders to work toward solutions on the complex drainage and estuarine loss problems in the lower watershed. Urban volun-

teers have contributed thousands of hours to repair neighborhood tributary streams. State agencies and Puyallup residents have seized opportunities to set back dikes and replace critical ecosystem functions wherever feasible. Marine Resource Committees and other local citizens groups are using volunteers to remove derelict fishing gear, inventory important spawning grounds for forage fish, and other activities to improve conditions in the nearshore. Each of these efforts demonstrates the commitment of the Puget Sound community to protecting and restoring salmon, and ensuring that these Northwest icons remain part of the landscape.

Detailed descriptions of the accomplishments toward salmon recovery goals at the watershed levels are contained within the watershed chapters.

"Our efforts to protect habitat stretch out over the next 10 years, but really we're talking about forever."

Sarah Spade, Jefferson Land Trust